Rajasthan Technical University (RTU)
Mechanical
(Machine Design)

M. Tech Program in Mechanical Engineering with specialization in
Machine Design

Courses

The theory subjects will be of maximum 125 Marks each having 25 Marks as course work and 100 Marks for University examination.

First Semester

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Code No.</th>
<th>Subject</th>
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<th>P</th>
<th>Marks</th>
<th>Ex. Hrs.</th>
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<td>1MEMD1</td>
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Second Semester

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Third Semester

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Fourth Semester

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List of Electives: (For 3MEMD11 & 3MEMD12)

Choose any two out of six given below.
3MEMD11&12.1:Composite Materials
3MEMD11&12.2:Fracture Mechanics
3MEMD11&12.3:Micro-Electrical and Mechanical Systems (MEMS)
3MEMD11&12.4:Tribology
3MEMD11&12.5:Pipe and Pressure Vessel Design
3MEMD11&12.6:Selection of Engineering Materials
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1MEMD1: ADVANCED SOLID MECHANICS

3L+1T MM:125 Ex.Hrs. 3


1MEMD2: ADVANCED VIBRATIONS

3L+1T MM:125 Ex.Hrs. 3

Vibration of continuous systems: Hamilton’s principle, Lagrange’s equations. Longitudinal vibration of bars, lateral vibration beams, vibration of membranes and plates. Wave motion in continuous systems.

Nonlinear vibrations: Phase space, singular points, limit cycle; Analytical methods, perturbation techniques, equivalent linearization; Duffing’s equation, jump phenomenon, Van der Pol’s equation. Stability criterion; Floquet’s theory, Hill’s and Mathieu’s equations, Bifurcation and chaos.

1MEMD3: NUMERICAL METHODS

3L+1T MM:125 Ex.Hrs. 3

1MEMD4: COMPUTER AIDED GRAPHICS AND DESIGN

3L+1T MM:125 Ex.Hrs. 3

Brief introduction to solid modeling: Fundamentals of Solid Modeling, Half-spaces, Boundary Representation (B-rep), Constructive Solid Geometry (CSG), Sweep Representation, Analytical Solid Modeling. Solid Manipulations

Methodology of interactive, graphical, engineering design; Discretization, optimization, simulation in CAED. Design of curves and surfaces. Design of volumes. Intersection of surface and interference of volumes.

1MEMD5: CAD LAB

3P MM:100 Ex.Hrs. 3

2MEMD6: FINITE ELEMENT ANALYSIS

3L+1T  Ex. Hrs: 3


2MEMD7: ROTOR DYNAMICS

3L+1T  Ex. Hrs: 3


2MEMD8: EXPERIMENTAL MODAL ANALYSIS

3L+1T  Ex. Hrs: 3

Introduction to modal testing: Presentation and properties of FRF data for SDOF system, undamped multi degree of freedom system (MDOF), proportional damping, hysteretic damping, viscous damping, characteristics and presentation of MDOF FRF data.

Mobility measurement techniques: Basic measurement system, structure preparation, excitation of the structure, transducers and amplifiers, analyzers, digital signal processing, use of different excitation types, calibration, mass cancellation.

Modal parameter extraction methods: Preliminary checks of FRF data, SDOF modal analysis- Peak amplitude, circle-fit method, inverse method, residuals, introduction to MDOF curve-fitting procedure - extension of SDOF method.

Derivation of mathematical models: Modal models, display of modal model, response models, spatial models, mobility skeletons and system models.

Application: Comparison of experiment and predication, correction or adjustment of models, structural modification, response predication and force determination.
2MEMD9: ADVANCED MECHANISMS AND MANIPULATORS

3L+1T            Ex. Hrs: 3

Classification of closed- and open-loop kinematic systems, Definition of mechanisms and manipulators, Kinematic constraints, Degree of freedom (DOF) and Mobility; DH parameters, Coordinate transformations, Matrix methods; Structural analysis and synthesis of mechanisms; Forward kinematics of robot manipulators with examples; Inverse kinematics; Jacobian and singularity; Alternative design solutions of mechanisms and manipulators; Evaluation and selection of optimum mechanism; Type and number synthesis, Design of mechanisms; Indexes of merit; Graphical, Algebraic and Optimization techniques.

2MEMD10: FEA LAB

3P                 MM:100            Ex.Hrs. 3

Laboratory work for the solution of solid mechanics problems and free vibration problems using FE packages.
Lamina constitutive Relations

Flat plates laminate constitutive relations

Lamina strength analysis
Elements of solid mechanics
The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation
Airy’s function- field equation for stress intensity factor.

Stationary crack under loading
Two dimensional elastic field- Analytical solutions yielding near a crack front- Irwin’s approximation- plastic zone size- Dugdaale model- determination of J integral and its relation to crack opening displacement.

Energy balance and crack growth
Griffith analysis- stable and unstable crack growth- Dynamic energy balance- crack arrest mechanism- $K_{1c}$ test methods- R curves- determination of collapse load.

Fatigue crack growth curve
1. **Introduction**: Production Engineering; Precision Engineering and Ultra Precision Engineering; Integrated Circuits (IC); Micro Electromechanical Systems (MEMS); Micro-sensors; Micro-actuators; Microelectronics Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS; MOEMS; Magnetic MEMS; RF MEMS; Micro fluidic Systems; Bio and Chemo – Devices; Nano-technology; Modeling and Simulation; MEMS Packaging and Design consideration; Micro instrumentation.

2. **Micromachining**: Introduction; Photolithography; Structural and Sacrificial Materials; other lithography Methods; Thin Film Deposition; Impurity Doping; Etching; Surface Micromachining; Bulk versus Surface Micromachining; Wafer Bonding; LIGA

3. **System Modeling and Properties of Material**: The need for Modeling; System Types; Basic Modeling Elements in Mechanical System; Basic Modeling Elements Electrical Systems; Basic Modeling Elements Fluid Systems; Basic Modeling Elements Thermal Systems; Translational Pure Mechanical System with Spring, Damper and Mass; Rotational Pure Mechanical System with spring, Damper and Mass; Modeling Hybrid Systems.


5. **Mechanical Sensors and Actuators**: Principal of Sensing and Actuation; Beam and Cantilever; Micro Plates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements; Strain measurements; Pressure Measurement; Flow Measurement; using Integrated Paddle – Cantilever Structure; Pressure Measurement by Microphone; Shear mode Piezo-actuator; Gripping Piezo-actuator; Inchworm technology.

6. **Thermal Sensors and Actuators**: Thermal Energy Basics and Heat Transfer Processes; Transistors; Thermistors; Thermo-devices; Thermo-couple; Micromachined Thermo-couple Probe; Peltier Effect Heat Pumps; Thermal Flow Sensors; Microhotplate Gas Sensors; MEMS Thermovessels; Pyroelectricity; Shape Memory Alloys (SMA); U Shaped Horizontal and Vertical Electro-thermal Actuator; Thermally Activated MEMS Relay; Microspring Thermal Actuator.

7. **Microfluidic Systems**: Applications; Important Considerations on Microscale Fluid; Fluid Actuation Methods; Dielectrophoresis (DEP); Electro-wetting; Electro-thermal Flow; Thermo-capillary Effect; Electroosmosis Flow; Optoelectro-wetting (OEW); Tuning Using Micro-fluidics; Typical Micro-fluidic Channel; Micro-fluid Dispenser; Micro-needle; Molecular Gate; Micropumps; The Continuous Flow System.

8. **Principal and introduction of Micro-Opto-Electromechanical system, Magnetic sensors and actuators and Radio frequency(RF) MEMS**